HEATING ELEMENT

The Government has rights in this invention pursuant to Contract No. F04701-77-C-0100 awarded by the Department of the Air Force.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to certain new and useful improvments in heating elements and, more particularly, to a method and apparatus using a high intensity, radiant energy heater operable in a normal ambient environment and capable of providing a high temperature isothermal region for tapering and fusing optical fibers.

2. Description of the Prior Art

In the processing of fibers, and particularly in the tapering and fusion of optical fibers, such as glass and quartz fibers, high intensity controlled temperature heating is required. Temperatures at least high enough to cause melting and some material flow of the fiber are required. When it is desired to fuse together two or more such fibers, the parallel fibers are heated to a relatively high temperature, e.g. 1,500° C. to about 2,000° C. Fibers thus formed and processed are effective as optical couplers, mixers, taps and attenuators.

In the processing of these optical fiber devices, it is necessary to fuse parallel fibers together and pull the fibers lengthwise to stretch and taper them under conditions of precisely controlled time and temperature. Such a taper may be formed intermediate or at the ends of the fibers. To create uniformity in the taper, a portion of the fiber is heated and pulled evenly. The taper is generally conical and is effective in reducing higher order modes of radiation in the fiber when used as a waveguide. It is often necessary to heat fibers over a substantial length, and the entire heated zone of the fibers must be at a uniformly high temperature during processing. It is also preferable that the fusion be conducted in an ambient atmosphere environment to facilitate ease of the fusion and other processing and to avoid the need for atmospherically controlled enclosures and special handling equipment.

Heretofore, high intensity flame heating was employed to heat parallel fibers for purposes of fusing them. However, flame heating is undesirable inasmuch as the flame itself contains impurities from the combustible source, and these impurities are introduced into the fibers during heating. Such contamination is highly undesirable, since the impurities increase the optical absorption in the fiber and, consequently, the attenuation of the optical signal in the fiber.

In the prior art, tubular heaters have also been employed. These tubular heaters comprise a cylindrically shaped heating element through which a fiber is passed and heated. A major disadvantage is that loading procedures require the fibers to be threaded through the tube. Such threading is time consuming, especially for fibers of multikilometer length. Clam-shell heaters have also been used, but these heaters are difficult to miniaturize and, when miniaturized, cannot provide the required isothermal environment.

Electric arc heating has also been employed and, while found useful for butt joining fibers, it cannot provide a long isothermal zone for parallel fusing of fibers with uniform and reproducible results, necessary in a production application.

Effective tapering has proved to be a substantial problem in that there has been no effective means or method to provide a uniform taper over a lengthy zone (e.g., more than one centimeter) of the fiber, and no means or method exists which is able to provide a taper on a reproducible basis with a high degree of uniformity. In order to accomplish the tapering in the prior art, flames and flame spreaders have been used. However, as indicated, the use of flames introduces undesirable impurities into the fibers. Further, since the heat of a flame is not uniform, the elongation and constriction resulting from pulling in a flame is not uniform and, hence, the resulting tapers are not uniform. Indeed, it has been found that only one out of fifty attempted tapers are acceptable and reproducible when using a flame and flame spreader.

As a result of these and other problems, effective heating of fibers in ambient atmosphere for their reproducible fusing and uniform tapering has heretofore not been available.

SUMMARY OF THE INVENTION

The above and other problems are overcome by the provision of a high intensity radiant energy heater which is preferably heated by electrical resistance and which is capable of operating in ambient atmosphere to provide a high temperture isothermal environment or zone for fiber fusion and tapering.

The heater generally comprises a shaped metal ribbon having a pair of side walls spaced apart from each other by a distance at least sufficient to receive a fiber. A bight portion or connecting wall connects end portions of the side walls together to form an elongate slot therebetween. The open end opposite the bight portion permits introduction of a fiber into the heating zone. Further, the portion of the two side walls adjacent the bight portion provides a large isothermal region which is ideal for heating of a relatively large length of the fiber. With this construction, it is possible to heat isothermally a lengthwise dimension of fibers equal to at least 50 to 100 times the diameter of the fibers.

In a preferred embodiment, heat loss reducing walls are respectively outwardly from, and generally parallel to, each one of the side walls. The heat loss reducing walls are connected to their respective side walls by connecting wall sections. These heat loss reducing walls reduce the external radiant loss from the isothermal region within the side walls by buffering this region from the cooler environment.

The heater is formed from a strip of a desired metal and bent to the desired configuration or shape. Thus, the heater is easily fabricated and provides all of the advantages described herein.

The present invention is also embodied as a method for pulling fibers using the disclosed heating element by placing the fibers under tension, thereafter heating them in the isothermal zone, and applying tension while being heated therein.

With the heater construction of the present invention, access to a large high temperature isothermal zone is facilitated with minimum heat loss to the environment. This easy access simplifies processing and eliminates the need for threading the fiber through the heater. The heater itself can be manufactured by simple tooling, and its simple construction assures ruggedness and consequent reduciton in initial, life cycle and other costs.

This invention possesses many other advantages and has other purposes which will become more clearly